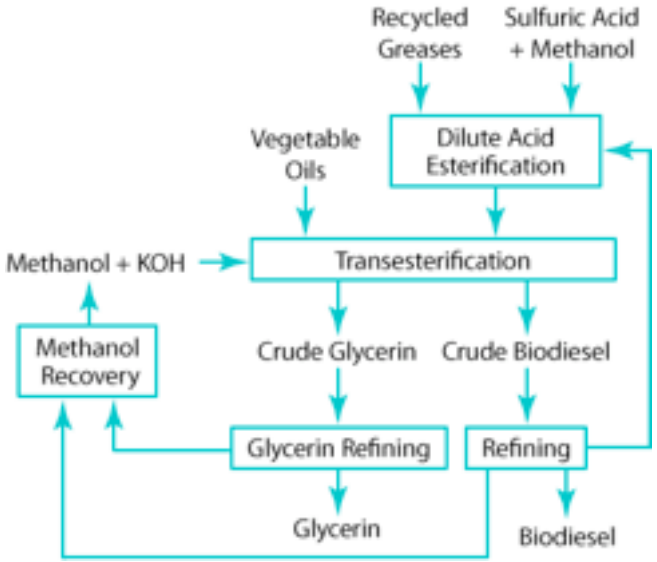
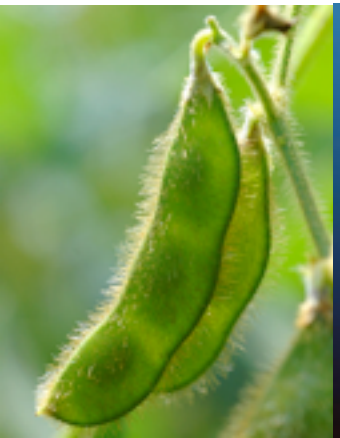
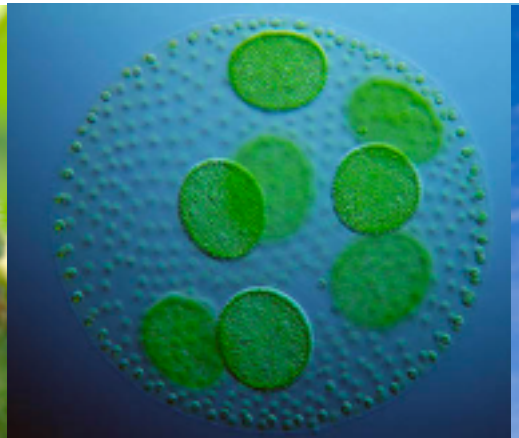
Water Usage in Biodiesel Production

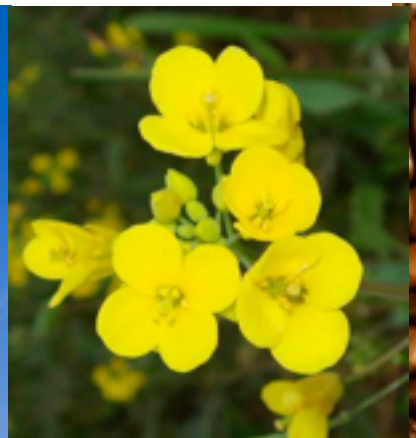
Tom O'Connor, PE

Water Usage Associated with Biodiesel

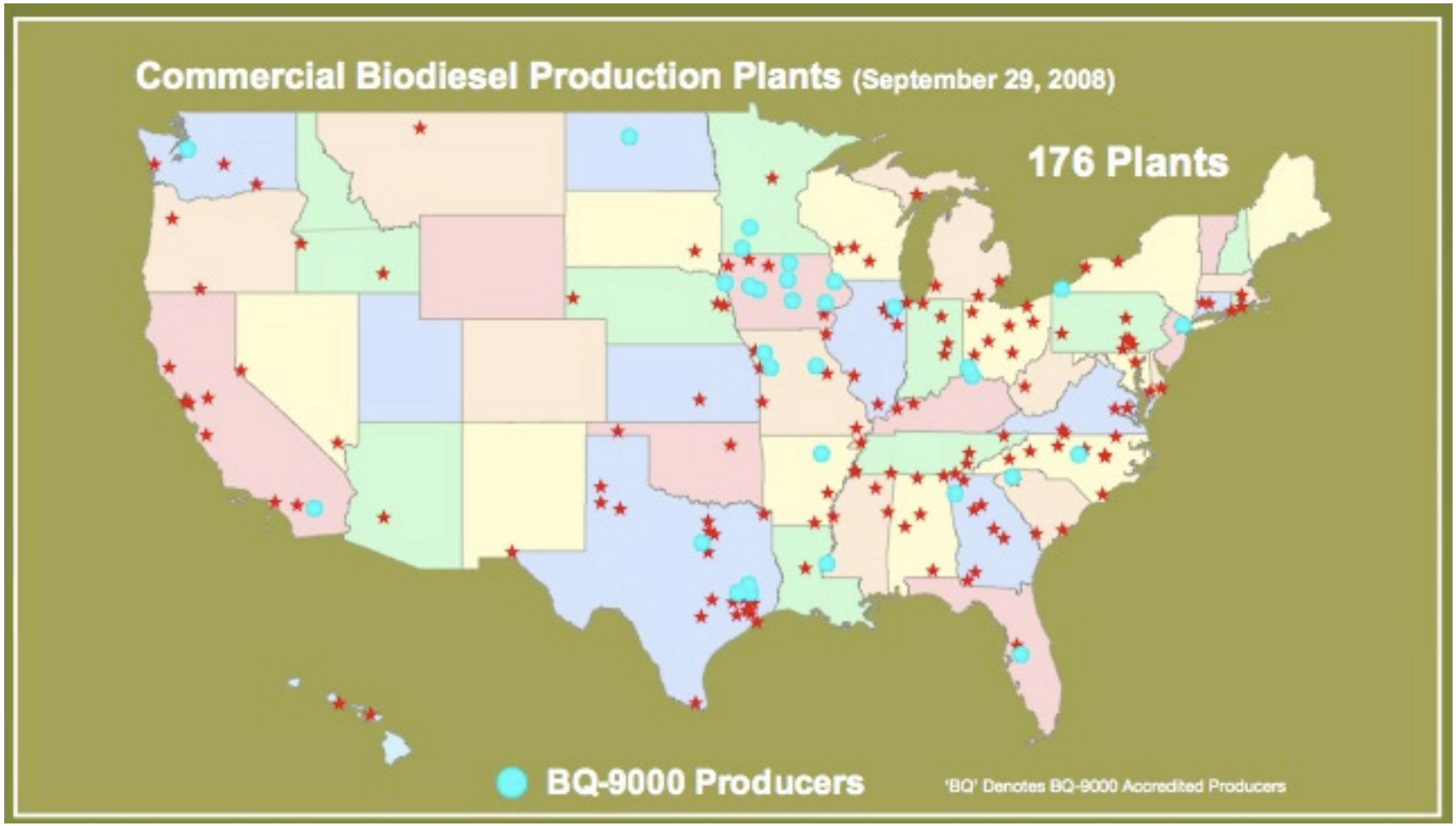
1. **Oil-to-Biodiesel Conversion Process**
2. **Water Use Associated with Feedstock**



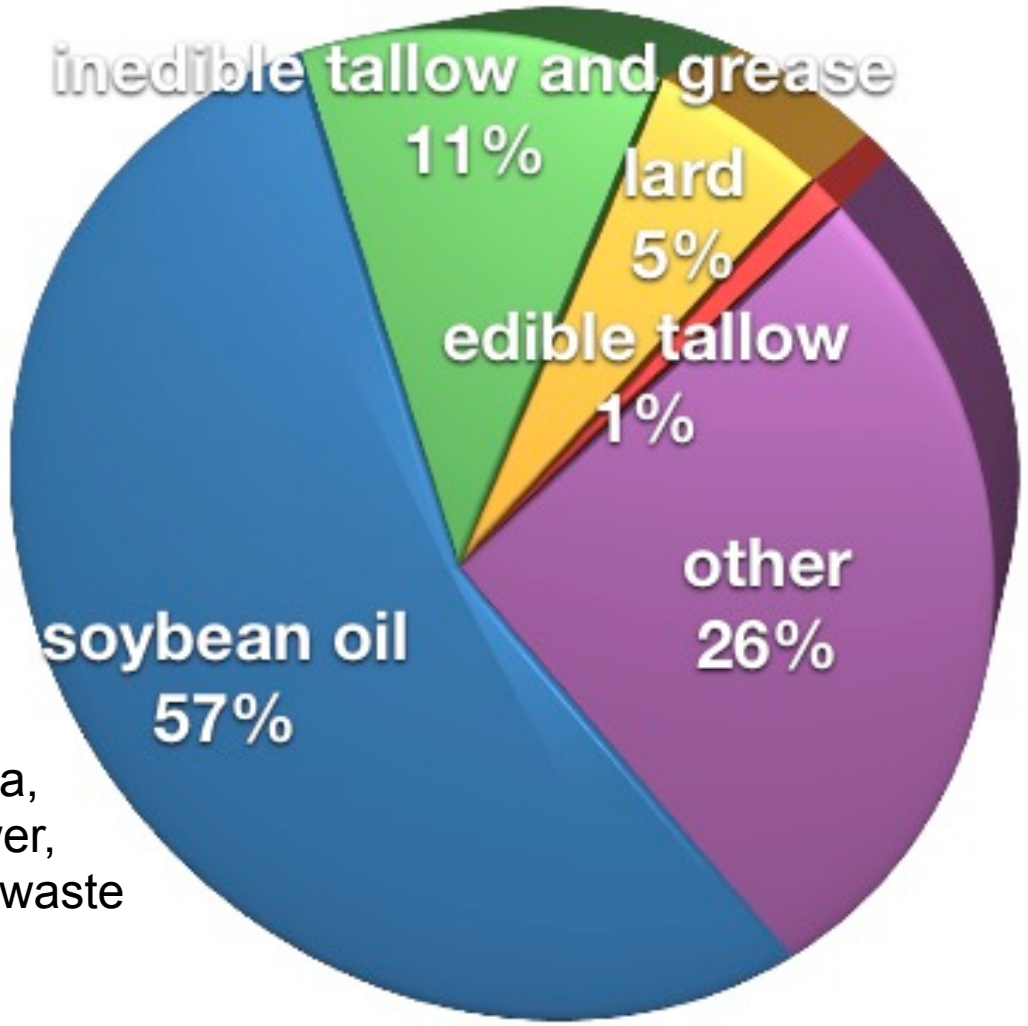






Biodiesel Producers



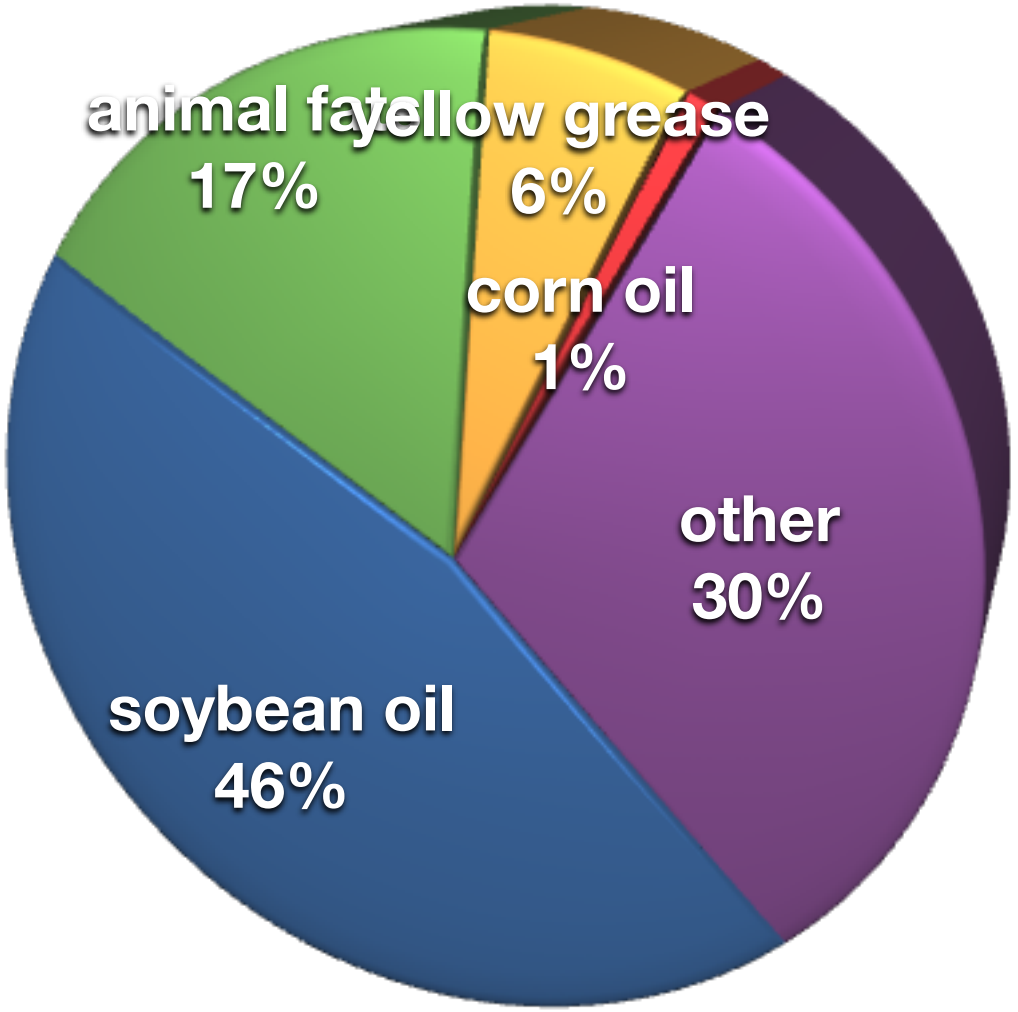
US Feedstocks, 2008



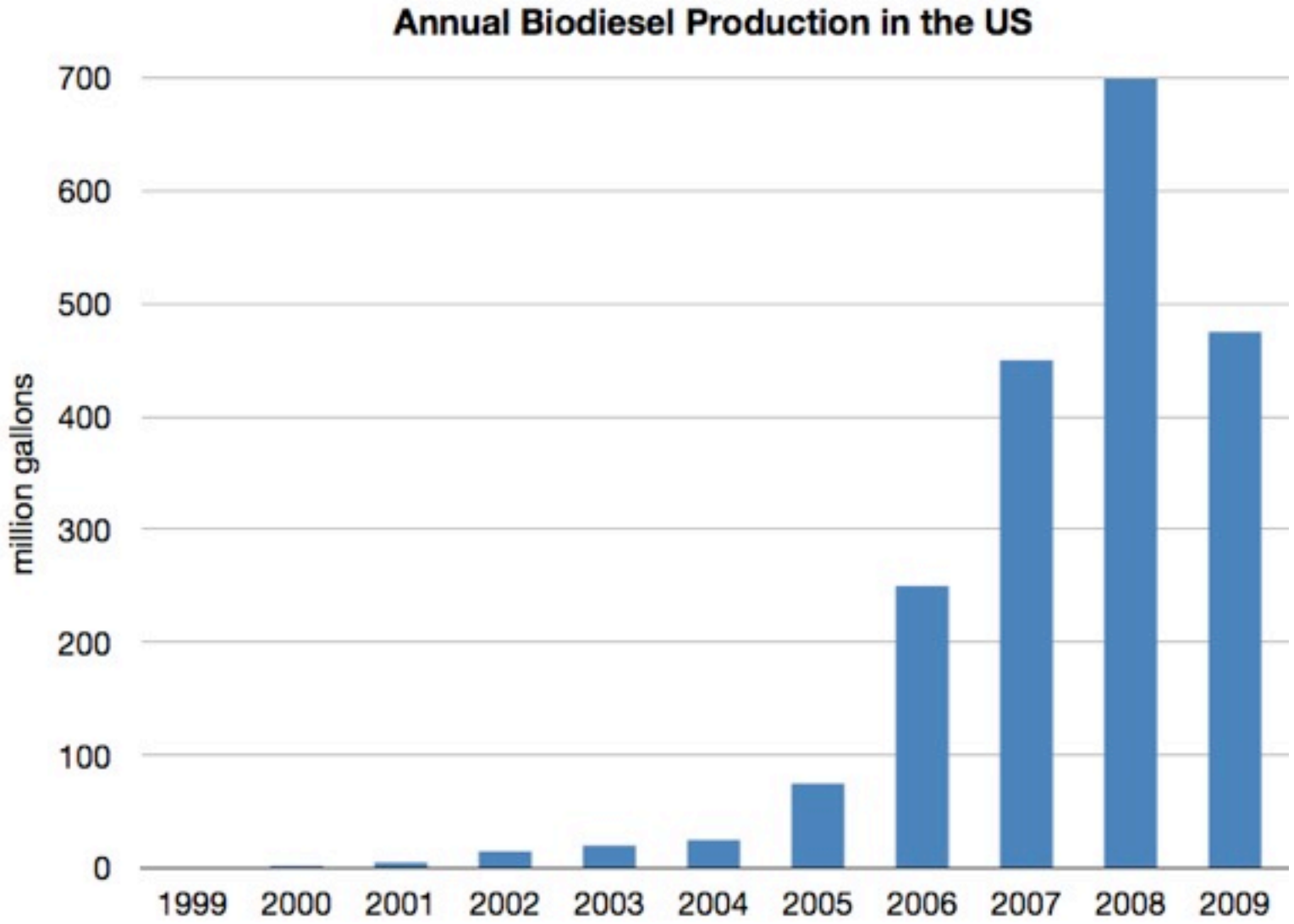
Other: Canola, palm, jatropha, jojoba, FOG from WWTP, mustard, sunflower, corn, coconut, flax, hemp, coconut, waste vegetable oil, spent coffee grounds, pennycress, algae...

Biodiesel Feedstocks in US, 2009

US Feedstocks, 2009



BIODIESEL
TM by the National Biodiesel Board

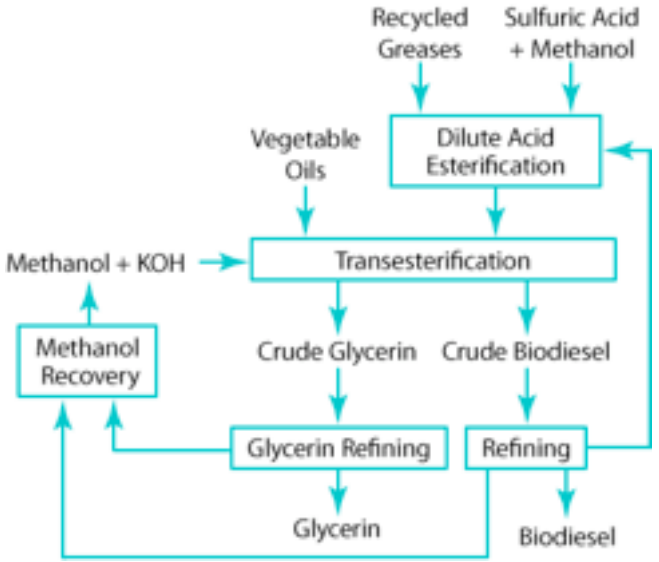


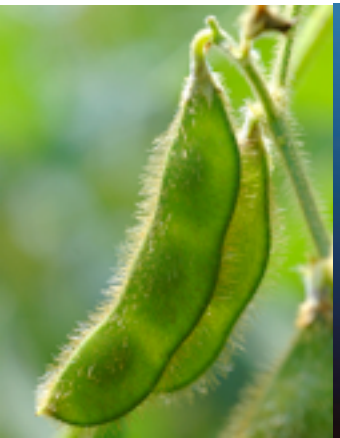
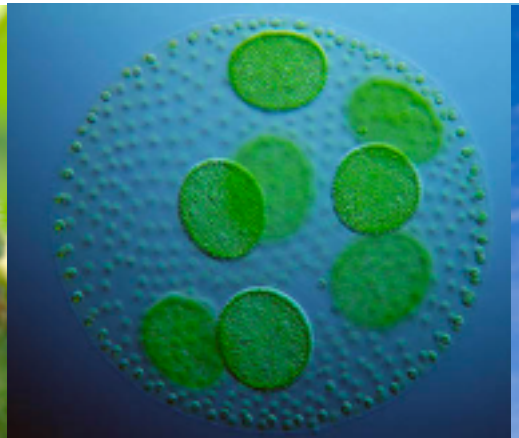
Biodiesel.org

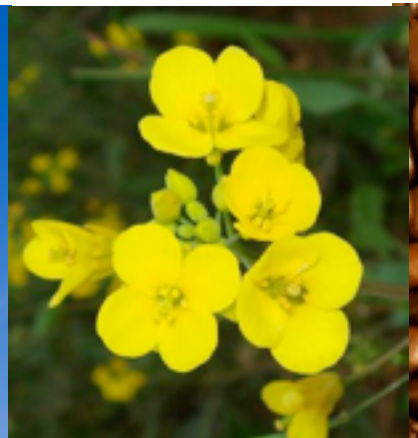
Water Usage Associated with Biodiesel

1. Oil-to-Biodiesel Conversion Process

2. Water Use Associated with Feedstock

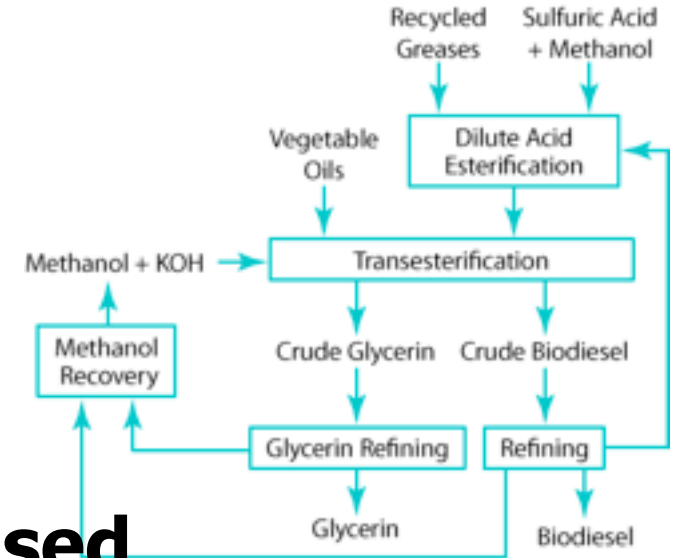





Water Usage Associated with Biodiesel

1. Oil-to-Biodiesel Conversion Process



Estimates range from

0.32 - 1 gallon of water used for each gallon of biodiesel produced.

(EPA, Sandia Labs, NBB producers' survey)

BIODIESEL

TM by the National Biodiesel Board

Production of 1 gallon of Biodiesel
Uses 0.32 - 1 gallon of water

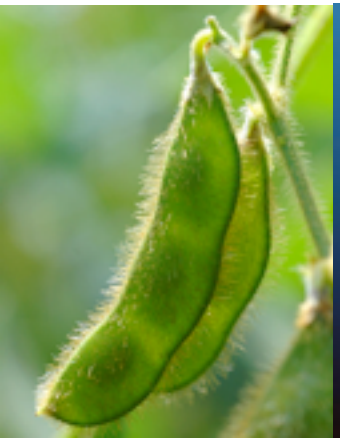
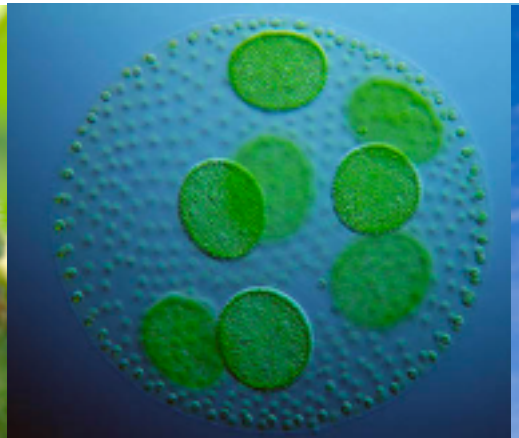
Entire US Biodiesel Industry
Used 150 - 475 MG of water in '09

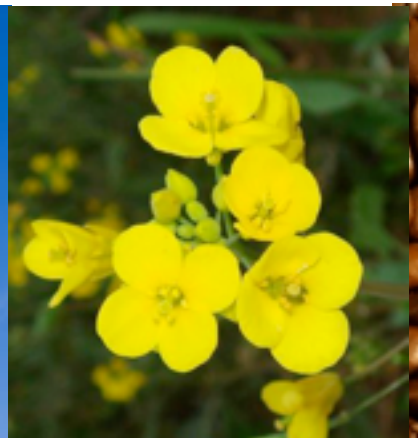
Golf Courses in Jefferson County, Colorado
Use 1,840 MG/year of Water (USGS, 2005)

Water Usage Associated with Biodiesel

2. Water Use Associated with Feedstock

- **Variables, feedstocks, regional issues**
- **More difficult to develop numbers**
- **46% of feedstocks are soy--let's look there**




Water Use Associated with Soybeans

Often-Cited Numbers

- **6,500 gallons of water per gallon biodiesel**
- **13,800 - 75,000 gallons water per MMBtu**

BIODIESEL
TM by the National Biodiesel Board

Further Review

Often-Cited Numbers

- **6,500 gallons of water per gallon biodiesel**
- **13,800 - 75,000 gallons water per MMBtu**

ENERGY DEMANDS ON WATER RESOURCES

REPORT TO CONGRESS ON THE INTERDEPENDENCY OF ENERGY AND WATER

U.S. DEPARTMENT OF ENERGY

DECEMBER 2006

ENERGY DEMANDS ON WATER RESOURCES

"Currently, the most water-intensive aspect of biofuel production is growing the feedstock. When that feedstock is corn or soy... and the feedstock is grown on irrigated land, the water consumption is quite high, as shown in Fig. V-4."

U.S. DEPARTMENT OF ENERGY

DECEMBER 2006

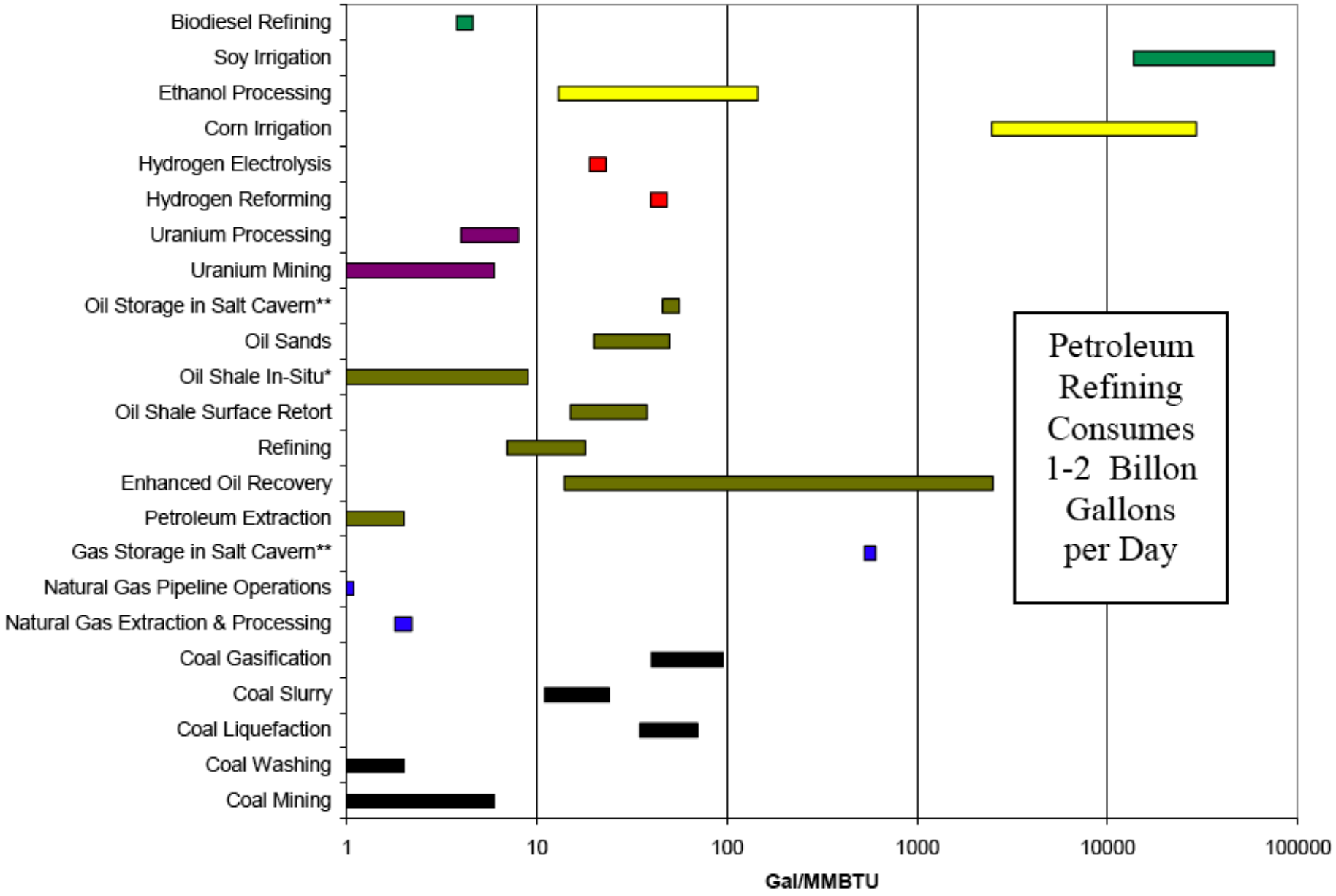


Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing

See Appendix B for Data References

ENERGY DEMANDS ON WATER RESOURCES

"On the other hand, biofuel feedstock produced ... from feedstocks grown without irrigation, or from feedstocks grown with nontraditional water, will have minimal freshwater use intensity associated with production.

This could provide significant volumes of bioenergy and biofuels in the future with low water use intensity (Perlak et al., 2005)."

DECEMBER 2006

ENERGY DEMANDS ON WATER RESOURCES

"Water use for **irrigated** soy production in the U.S. varies... with a national average of 0.8 acre-feet of water (USDA, 2004a).... The average water use was 6,200 gallons of water per bushel of soy..."

U.S. DEPARTMENT OF ENERGY

DECEMBER 2006

Energy Demands On Water Resources

"Water use for **irrigated** soy production in the U.S. varies... with a national average of 0.8 acre-feet of water (USDA, 2004a).... The average water use was 6,200 gallons of water per bushel of soy..."

2009 UPDATE: The national average decreased to 0.7 acre-feet of water, and due to higher yields, the average water use is 4,655 gallons of water per bushel of soy.

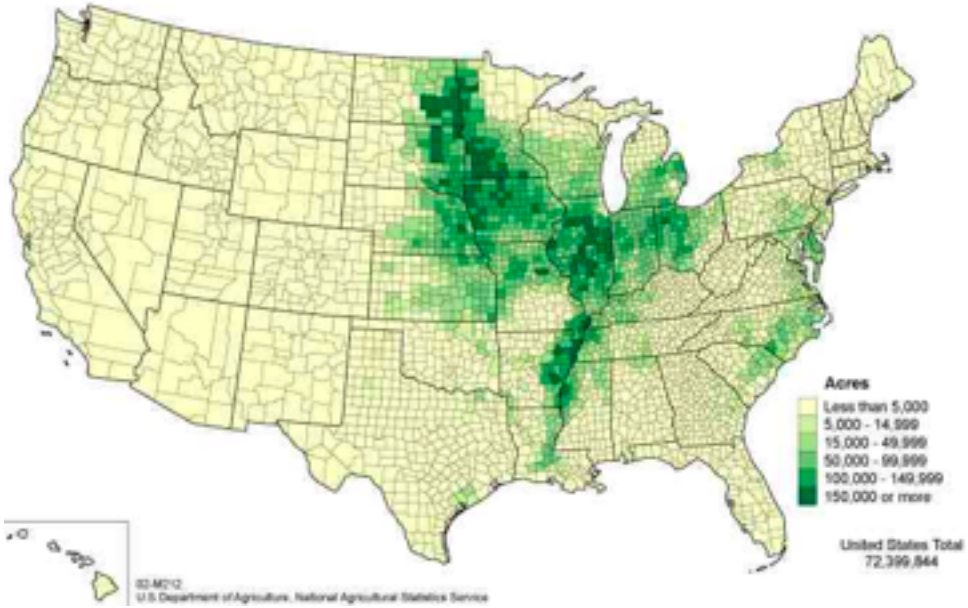
Big Factor: Irrigated or Not?

If irrigated, is it:

- **efficient**
- **responsible**
- **productive**
- **sustainable?**

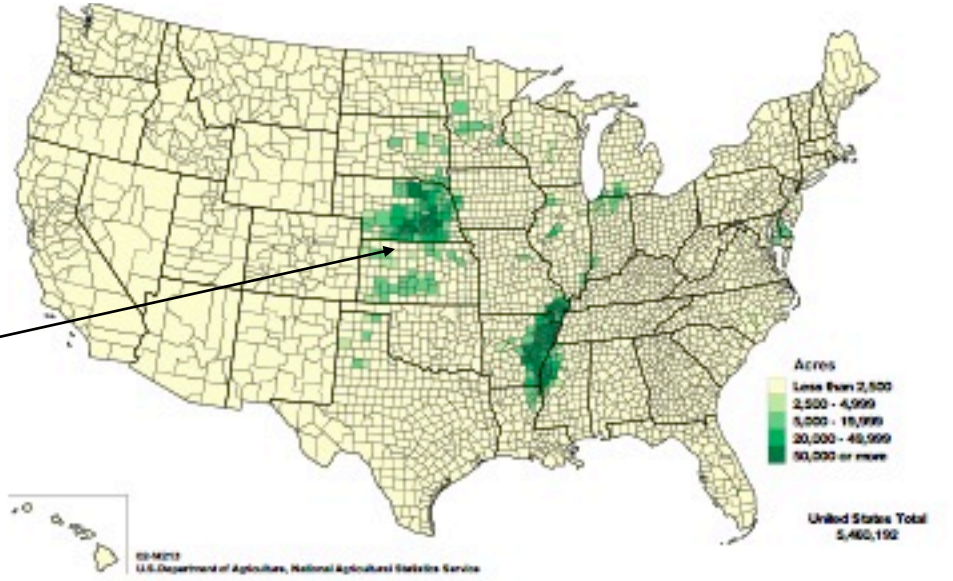
USDA 2003
Farm and Ranch Irrigation Survey

Planted Soybean Acres:
72.4 Million



7.5% of Soybeans were Irrigated

Irrigated Soybean Acres:
5.5 Million



Irrigation in Nebraska produced yield improvements of at least 38% (+15 bushels/acre).

USDA 2008
Farm and Ranch Irrigation Survey

Planted Soybean Acres:
Decreased from 72.4 to 63.9 Million

Irrigated Soybean Acres:
Increased from 5.5 to 7 Million

No Cool Maps This Time

Irrigation Water Usage Decreased from 0.8 to 0.7 acre-ft/acre
% of Acres Irrigated Increased from 7.5 to 11%

Recent USDA Data

YEAR	total acres of soybeans harvested	total yield, bushels	irrigated acres	bushels/acre	% acres irrigated (calc.)	irrigation water per acre (acre-ft)
1997*	67,773,274	2,560,330,804		37.8		
2002*	72,399,844	2,707,719,216	5,460,192	37.4	7.5%	
2003**			5,346,276	48 (irrigated)	7.4%	0.8
2007*	63,915,821	2,582,423,697	5,237,075	40.4	8.2%	
2008**			7,044,546	49 (irrigated)	11.0%	0.7

* 2007 Census of Agriculture, United States Summary and State Data, Volume 1, Geographic Area Series, Part 51 (USDA, February 2009)

**2007 Census of Agriculture, Farm and Ranch Irrigation Survey (2008), Volume 3, Special Studies, Part 1 (USDA, November 2009)

Recent USDA Data

1,606,830 MG total irrigation water /

2,582,423,697 total bushels produced =

622 gallons irrigation water per bushel

Aggregation of:

89% of soybeans at zero gal/bushel

11% of soybeans at 4,655 gal/bushel

Water Use Associated with Soybeans

soybean:

20% oil,

80% meal

Allocation of Inputs to Outputs

Water Use Associated with Soybeans

Soybean crush:

20% oil,

80% meal

Conversion of soybean oil:

89% biodiesel,

11% glycerin

(NBB producers' survey)

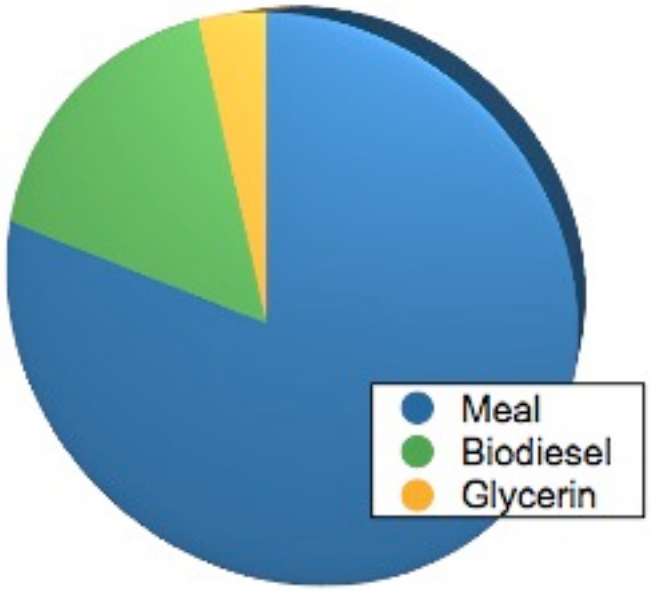
Water Use Associated with Soybeans

Allocate Inputs by Mass of Outputs:

80% meal

17.8% biodiesel,

2.2% glycerin



Water Use Associated with Soybeans:

Aggregate of Irrigated and Non-, with Coproducts

622 gallons of irrigation water/bushel

17.8% of the bushel becomes 1.4 gal biodiesel

79

gallons of water/gallon of biodiesel

Water Use Associated with Soybeans:

Aggregate of Irrigated and Non-, with Coproducts

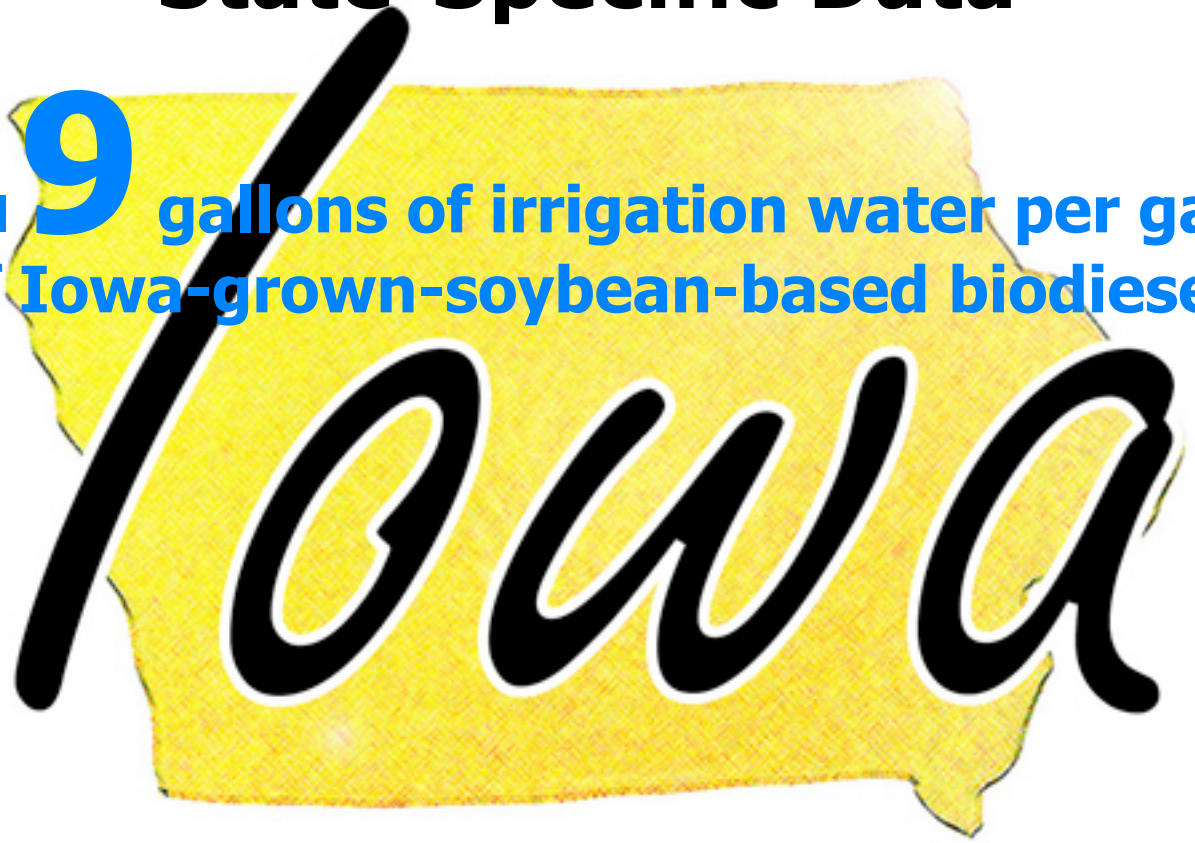
79 gallons water per gallon biodiesel =

79 gallons water per 130,000 Btu =

608 gallons per MMBtu

Water Use Associated with Soybeans: State-Specific Data

1.9 gallons of irrigation water per gallon of Iowa-grown-soybean-based biodiesel



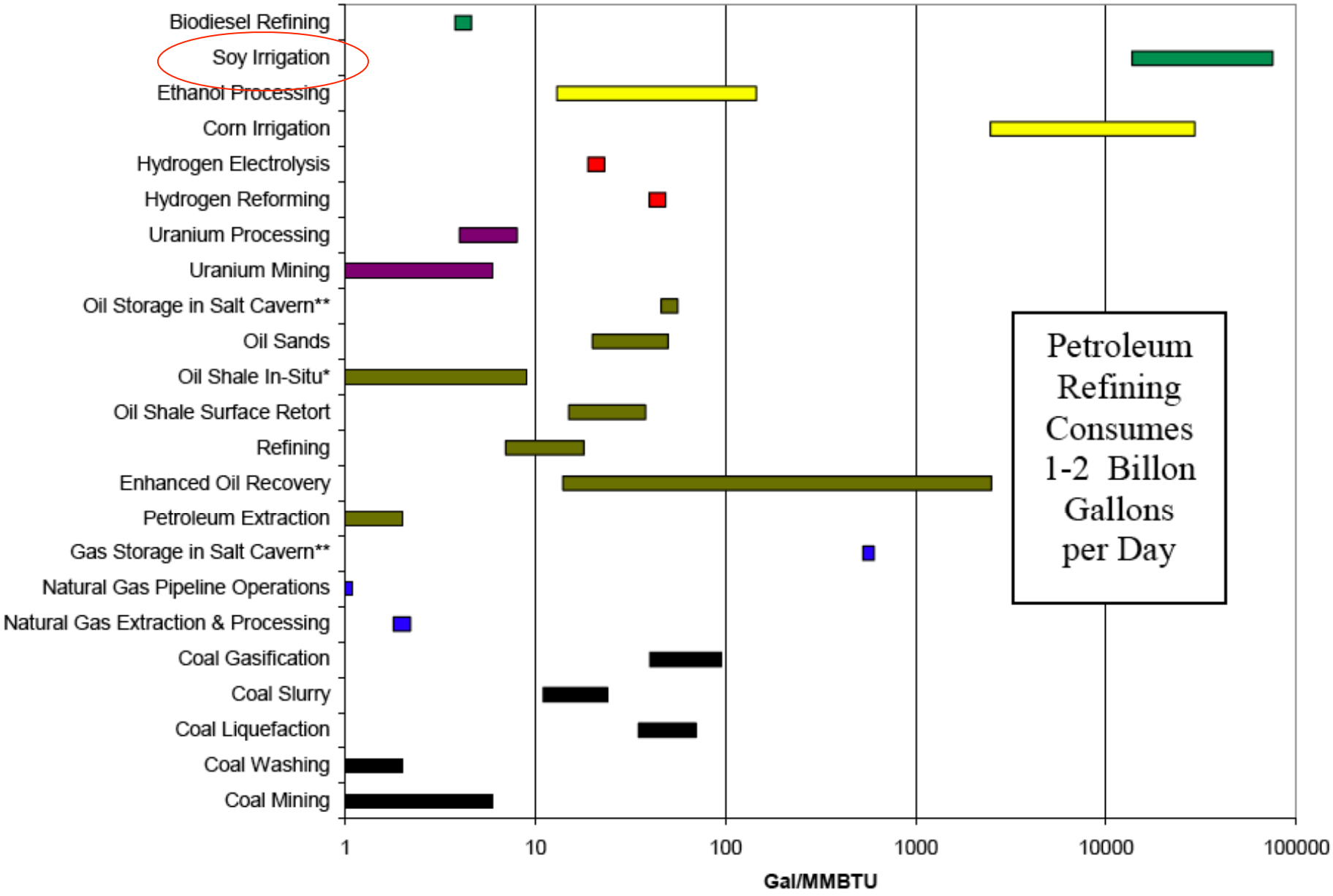


Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing

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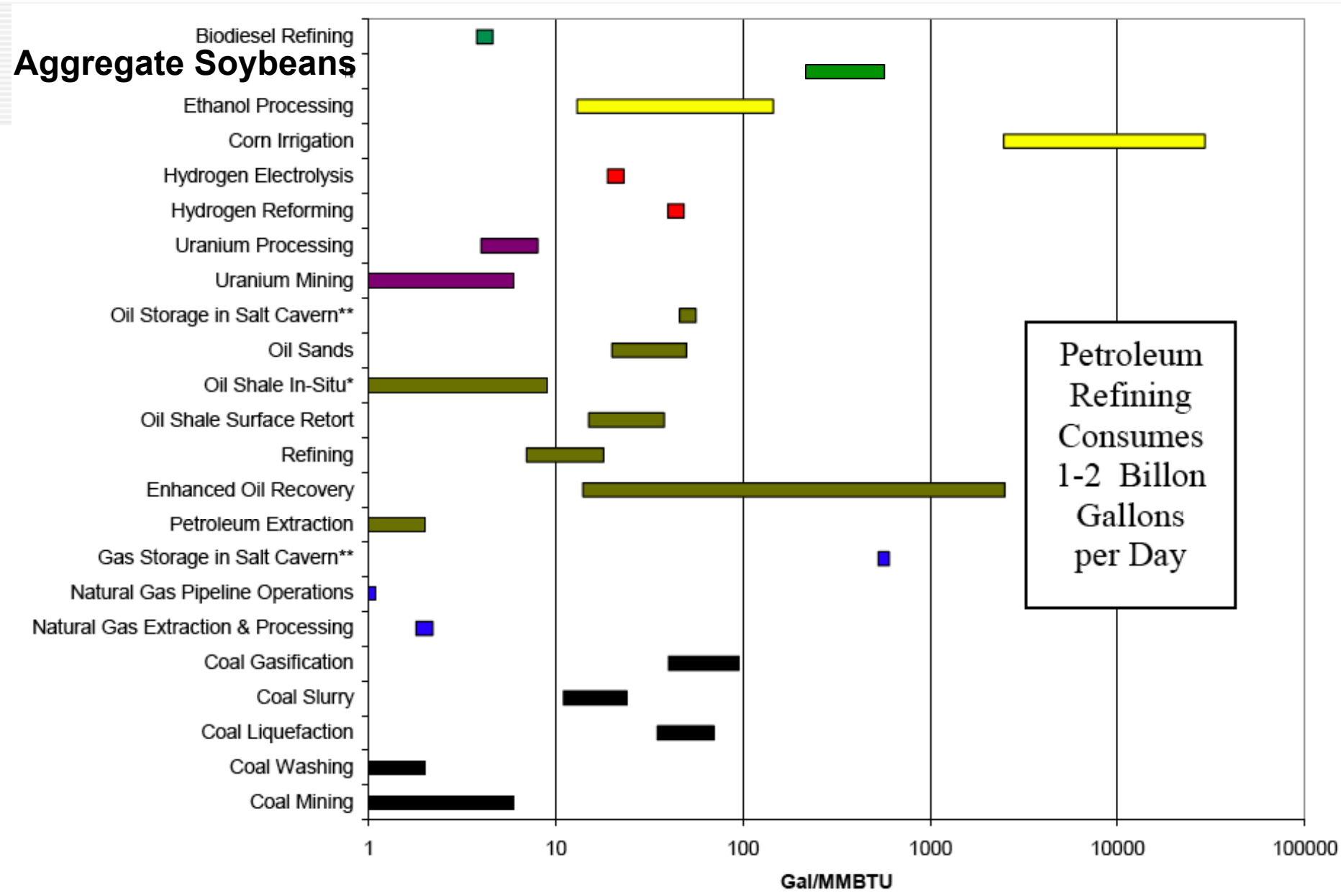


Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing

See Appendix B for Data References

Soybean Agriculture & Water Quality

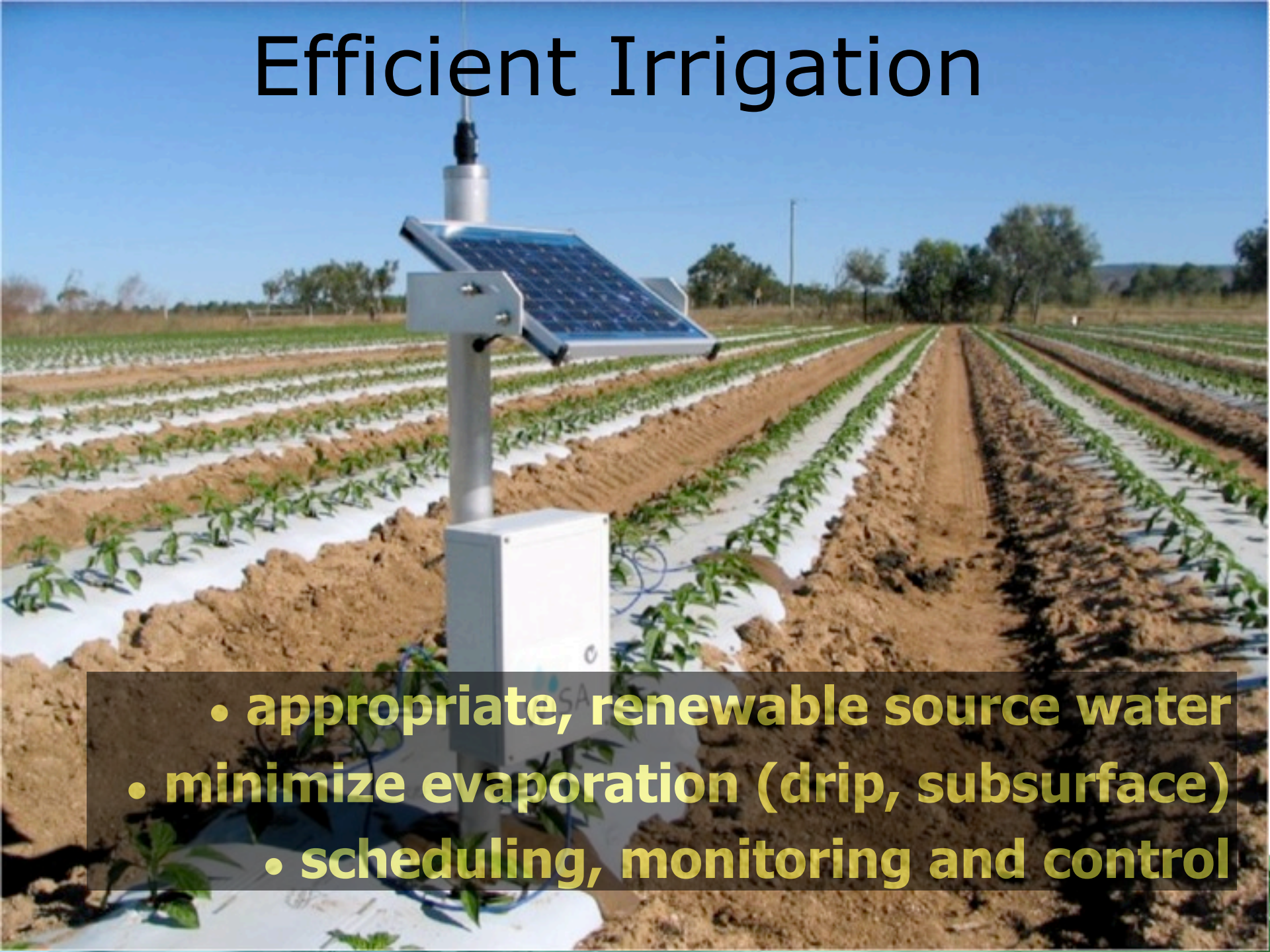
- **Low Fertilizer Requirements**

  (Soy fixes atmospheric nitrogen)
- **Low Pesticide Requirements**
- **Low Irrigation Requirements**

Water and Biodiesel

- Conversion process uses minimal water
- Irrigation is the major factor
- Soybean irrigation inputs are allocated over all outputs (meal, biodiesel, glycerin)
- 79 gallons irrigation water per gallon soy biodiesel, plus a gallon for processing…
- 80 gallons of water per gallon biodiesel

Efficient Irrigation



- appropriate, renewable source water
- minimize evaporation (drip, subsurface)
- scheduling, monitoring and control

NBB Sustainability Principles

1. Biodiesel production shall follow all applicable laws of the jurisdiction in which it is produced.
2. Biodiesel projects shall be developed and operated under appropriate, transparent, and participatory processes that involve all relevant stakeholders.
3. Biodiesel shall contribute to climate change mitigation by significantly reducing lifecycle greenhouse gas emissions as compared to fossil fuels. Producers shall strive to continuously improve that reduction.
4. Biodiesel production shall support human rights and labor rights, and shall ensure safe and decent working conditions.
5. Biodiesel production shall contribute to the social and economic development of local communities.
6. Biodiesel production shall strive to improve food security.
7. Throughout the supply chain, the biodiesel industry shall implement management systems that maintain and strive to improve biodiversity, areas of High Conservation Value, and the quality of natural resources such as soil, air, and water.
8. Biodiesel production shall respect natural resource rights, such as land and water rights.
9. All participants throughout biodiesel supply chain shall be dedicated to the ideal of continuous improvement. Members shall, through ongoing efforts, make advancements in the economic, social and environmental performance of the industry.

Biodiesel Sustainability Principles

7. Throughout the supply chain, the biodiesel industry shall implement management systems that **maintain** and strive to **improve** biodiversity, areas of High Conservation Value, and the **quality** of natural resources such as soil, air, and **water**.

8. Biodiesel production shall **respect** natural resource rights, such as land and **water rights**.

The Next Question…?

What does it mean to "use" water?

Water Usage in Biodiesel Production

Tom O'Connor, PE